



200314

000015



UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 5
77 WEST JACKSON BOULEVARD
CHICAGO, IL 60604-3590

MEMORANDUM

DATE: March 26, 1997

SUBJECT: Lead Risk Evaluation for the Master Metals, Inc. Site, Cleveland, Ohio

FROM: Pat Van Leeuwen
Toxicologist
Office of Superfund

TO: Ababi Harris
Remedial Project Manager

This memorandum presents a streamlined risk evaluation to support remedial actions at the Master Metals, Inc. (MMI) site in Cleveland, Ohio. The purpose of this memorandum is to identify the potential for human health risks at the site, based on the detection of highly elevated soil lead levels and potential pathways for exposure to this contaminant. In addition, risk-based clean-up goals for further response action are developed.

1.0 Background

The Master Metals Site is located at 2850 West Third Street, Cleveland, Cuyahoga, Ohio. The MMI property is approximately triangular in shape and consists of two contiguous parcels totaling approximately 4.3 acres. The site is in a heavily industrialized area, bounded on the northwest by rail yards owned by the Baltimore and Ohio railroad, on the south by a dead-end road, and on the east by West Third Street. The Cuyahoga River is approximately 0.5 miles east of the site and flows north toward Lake Erie. Topographic maps suggest that the direction of groundwater and surface water flow in the vicinity of the MMI site is toward the northeast. The water table is at a depth of approximately ten feet below the ground surface.

The MMI facility is located on top of slag fill material that was reportedly deposited throughout the area during industrial development in the early 1930s. NL Industries, Inc. Operated at the site from 1932 to 1979. MMI purchased the site in 1979 and continued to use the site as a secondary smelter. The MMI facility ceased operations in 1993 after a history of environmental violations.

The site previously included an office building, numerous storage areas (including a battery storage area), two baghouses and a deteriorated smelter building. In 1997, decontamination and demolition operations were begun, as part of a time-critical removal at the Master Metals site. All building except the office building have been razed. All remaining feed-stock and debris materials have been either decontaminated and/or treated and transported and disposed of as either special waste or hazardous waste. Approximately 90 percent of the current onsite surface is covered by concrete with fill materials, consisting of sand, cinders, slag and gravel, covering the remaining surface areas.

2.0 Site Investigation

2.1 Historical Sampling This section summarizes sampling activities conducted at the Master Metals Site prior to and during the time-critical removal actions in 1997.

A Phase II environmental assessment of the MMI site was conducted by Compliance Technologies, Inc. (CTI) in 1990. Thirty-four subsurface soil samples were collected from two sampling depths, two to five feet and eight to ten feet, and analyzed for eight RCRA metals (arsenic, barium, cadmium, chromium, lead, mercury, selenium and silver). Greatly elevated levels of lead were detected in these samples; slightly elevated levels of chromium and cadmium were also found in 17 of the 34 samples.

In 1992, Ecology and Environment, under contract from U.S. EPA, collected seven surface soil samples. Again, analysis of the samples showed the presence of lead concentrations 1-2 orders of magnitude higher than all other metals, as well as detection of other metals, including arsenic, barium, cadmium and chromium. As part of a time-critical removal conducted by ENTACT, all exposed on-site surface areas (those not covered by concrete) were excavated to a minimum depth of two feet or until slag fill materials were encountered. The XRF extent of contamination survey results indicate an average soil lead concentration of 7,550 mg/kg remaining after excavation of forty-eight grids, with a range of 257 mg/kg to 35,205 mg/kg. (See Table 2-1, Engineering Evaluation and Cost Analysis (EE/CA) Data Report for the Master Metals, Inc. Site, January 19, 1998, for a complete data summary.) Five supplemental boring samples in the drum, container and battery storage areas were collected to define the lateral extent of contamination, and two boring samples from the area adjacent to the furnace building were collected to assess residual contamination.

To determine if facility contaminants were subject to airborne transport, Ecology and Environment collected samples in July, 1992, proximate to the facility property. Analysis of

these samples revealed total lead levels of 24,000 to 43,100 mg/kg. This information prompted an XRF survey, conducted around the perimeter of the facility, to fully assess the potential for lead impacts. The outside fence perimeter of the facility was divided into minimum 100 foot lengths and perimeter locations behind the roundhouse into 50 foot lengths, for the surface XRF evaluation. In addition, one boring sample was collected approximately three feet from each side of the facility at the XRF location exhibiting the highest XRF lead reading. The first sample interval exhibiting an XRF value less than 1000 mg/kg was submitted for laboratory total metal analysis (arsenic, cadmium, chromium and lead).

Off-site surface samples were also collected in July, 1993, from locations 0.4 miles northwest and west of the site. These samples were collected near residential areas and showed soil lead concentration of 148 to 1,850 mg/kg.

2.2 Current Sampling The EE/CA Sampling and Analysis Plan (dated October 1, 1997) contains the procedures and methods to determine the extent of the remaining on-site and off-site lead contamination at the Master Metals Site. The results of this sampling and analysis are reported in the EE/CA Data Report for the Master Metals, Inc. Site, dated January 19, 1998.

On-site samples were collected to assess the lateral extent of contamination from the drum storage and battery storage areas. These samples consisted of seven four-foot borings (ONS-01 through ONS-07) collected in the vicinity of the Battery Storage Area, Drum and Container Storage Area, and the Former Rotary Furnaces. Due to compaction, actual depth of recovery was three feet or less. The segments were screened for total lead by XRF, and the results are shown in Table 3-2 of the 1998 EE/CA Data Report.

Laboratory verification data for the total arsenic, total cadmium, total chromium and total lead analyses are shown in Table 3-3 of the 998 EE/CA Data Report.

Perimeter XRF lead survey samples (designated X-1 through X-19) were collected along Quigley Avenue to assess the potential for airborne lead migration from Master Metal operations. Soil borings were also collected from around the facility perimeter to assess contamination at depth; sample locations were based XRF results and are labeled PS-01 through PS-04. At boring locations PS-01, PS-02 and PS-03 the lead XRF screening value of 1000 ppm was reached in the 12"-24" depth segment, while in boring PS-04 it was reached at the 24" to 36" depth segment. The data is reported in Table 3-1 of the 1998 EE/CA Data Report.

In December 1990, four groundwater monitoring wells were installed on the Master Metals site, and groundwater samples collected. All four monitoring wells were located for the current EE/CA sampling; however only three were found to be intact and suitable for sampling. Three groundwater samples were collected and analyzed for total and dissolved metals.

3.0 Lead Contamination at the Site

3.1 Data Evaluation

Analytical results from the analysis of soil and water from onsite and perimeter samples revealed the presence of several metals, including arsenic, barium, cadmium, chromium and lead. Lead was detected at extremely elevated concentrations. Therefore, this assessment focuses on the lead contamination levels remaining at the site and the risks posed by this contaminant. The migration of lead contaminated surficial soils offsite are discussed in relation to perimeter sample results in this assessment.

The XRF analysis of the boring sample segments shows good agreement between the three readings taken on each segment. The XRF readings and soil descriptions, which indicate that much of the material at three to four feet depth is slag, support the conclusion that there is significant lead contamination at depth on-site. This is consistent with information collected from soil excavation and XRF surveying done as part of the time-critical removal actions (described in section 2.1 of this report).

The average XRF lead measurements varied greatly with the location of the sample and depth of the sample. The concentrations range from the low value of 110 mg/kg (sample ONS-06) to 34,320 mg/kg (sample ONS-07) in the 0-6" segment; the mean value for all seven surface soil samples is 14,574 mg/kg. The concentrations in the 6"-12" segment range from 462 mg/kg (ONS-04) to 15,353 mg/kg (ONS-06), with a mean value of 5679 mg/kg. The lead concentrations in the 12"-24" segments range from 52 mg/kg (ONS-04) to 12,580 mg/kg (ONS-01), with a mean value of 2954 mg/kg. Data from the 24" to 36" depth is too sparse to mention here, but is included in the analysis.

The nineteen perimeter XRF surface soil measurements all show elevated levels of lead. The sample lead concentrations range from 931 mg/kg (X-8) to 36,587 mg/kg (X-10); the mean perimeter surface soil lead concentration outside the fence is 8,664 mg/kg. Boring samples were collected at four locations: X-4 (3,360 mg/kg), X-7 (10,307 mg/kg), X-10 (36,587 mg/kg) and X-12 (21,237 mg/kg). The lead concentration appears to decrease with depth in the perimeter boring samples. Samples segments which met the 1000 ppm screening level were submitted for laboratory analysis; in three of four samples, the reduction in lead concentration was reached in the 12"-24" sample and in one case in the 24"-36" sample. This lead contamination pattern in surface soil samples taken outside the fence is suggestive of an airborne source.

The comparison between all XRF measured total lead concentration values and Laboratory measured total lead concentration values, shown in Table 3-4, create uncertainty over the accuracy of the lead concentrations reported by XRF analysis. A 2.65 fold average increase in lead concentration in samples analyzed in the Laboratory versus samples analyzed by XRF was seen in six of seven onsite samples, whose XRF measurements ranged from 110 mg/kg to 12,580 mg/kg. One sample (ONS-04-12), which was not included in the averaging, exhibited a 26 fold increase after laboratory analysis. For the four perimeter samples (whose XRF reading

ranged from 72 mg/kg to 409 mg/kg), the average difference between XRF and laboratory values was less pronounced (1.2).

Two additional problems are raised by the use of the EE/CA surface soil data described above for lead risk assessment. The usual pathway of exposure to soil dust is incidental ingestion (see expanded discussion which follows); the assumption inherent in this pathway is that soil which is available for ingestion comes from the surface soil dust fraction - i.e., the top two inches of soil and that fraction of total soil which passes through a 250 micron (100 mesh) sieve. The use of surface soil samples collected over a six inch depth introduces an unknown dilution for sites where the primary source of contamination is surficial. The reduction in lead concentration with depth seen in the boring samples collected onsite and in the perimeter areas indicate that this is the case at the Master Metals Site. In addition, numerous analyses of both total and fine soil lead fractions have shown that lead concentrations tend to increase in the fine particulate fraction, especially if the source is airborne deposition. Stern has suggested in his lead model that an adjustment to the total soil lead concentration be included in the risk calculations to reduce some of the under prediction caused by the use of total soil lead data. Again, this problem would seem to be relevant to the Master Metals site. For the reasons stated above, it is expected that any risk calculations performed using the EE/CA data collected at this site will be underestimations and that they will be considered to be such.

Nine surface soil samples were collected at locations along Quigley Avenue to allow further assessment of potential airborne lead impacts from the Master metals facility. The sample location criteria were based on the likelihood of impact by commercial or industrial operations. The samples were analyzed in the laboratory, and show a lead concentration range of 85 mg/kg to 1,200 mg/kg.

3.2 Populations of Concern

Lead is a contaminant that can impact the health of both children and adults. A typical lead risk assessment focuses on the risk to young children in a residential setting. Children are generally considered to be the population at greatest risk to the toxic effects of lead due to their behavior characteristics (including increased hand-to-mouth activity and pica behavior) which lead to higher lead intakes than those seen in older children or adults, their greater absorption efficiency for lead from the gastrointestinal tract than other age groups, and the increased susceptibility of the developing nervous system to the adverse effects of lead.

OSWER Directive # 9355.4-12 "Revised Interim Soil Lead Guidance for CERCLA Sites and RCRA Corrective Action Facilities" (EPA 1994) recommends a residential soil screening level for lead of 400 mg/kg, and use of the Integrated Exposure Uptake Biokinetic Model for Lead in Children, version 0.99d, for further evaluation of a site when this level is exceeded in a residential land use. The EPA Technical Review Workgroup for Lead has provided guidance for conducting risk evaluations for older populations in their "Recommendations of the Technical Review Workgroup for Lead for an Interim Approach to Assessing Risks Associated with Adult

Exposures to Lead in Soil” (EPA 1996). This latter document has been supplemented by an additional memo which presents the Interim Adult Approach equations in a form more applicable to the risk calculation.

The Master Metals, Inc. Site is located in a heavily industrialized area, and the present and anticipated future use of this property is commercial/industrial. This assessment therefore focuses primarily on the risk from lead exposure to a full time worker population. In addition, because construction activities related to redevelopment of the site present a real likelihood, the exposure to a construction worker is also evaluated in this assessment. The TRW Interim Adult Approach is used in both evaluations.

3.3 Exposure Pathways and Assumptions

The primary exposure pathway from lead contaminated soil is incidental ingestion. The dermal pathway is not considered to be significant because lead is not well absorbed through the skin; it is not considered in this assessment. Another exposure pathway that is not included in the lead risk assessment is dust inhalation. Direct inhalation of lead-contaminated soil is considered to represent a minor source of exposure when compared to direct ingestion.

The future worker exposure is considered to consist of onsite exposure to outdoor soil dust as well as exposure to soil-derived indoor dust, as described in the Interim Adult Methodology document. In the case of the Master Metals site both fractions are represented by the 0-6" surface soil XRF measurement data. A range of risks to specific onsite locations, assuming that worker activity is heavily concentrated in one site location, is evaluated; in addition, a more traditional assessment which considers that worker activities result in equal exposure to every onsite location on a routine basis, is also evaluated. A normal 8 hour workday, five days per week, resulting in a 250 day per year exposure for a full-time worker is assumed. A soil ingestion rates of 50 mg/day is assumed for non-contact intensive occupational exposure (deskwork), consistent with EPA guidance. Other parameter values pertinent to the worker scenario are shown in Table 1.

The onsite construction worker exposure is considered to consist of exposure to both surface and subsurface soil lead contamination, which is represented in this assessment by the depth-weighted soil lead concentration at each location and by the average overall onsite lead concentration. The construction scenario is assumed to represent heavy exposure, as characterized by an ingestion rate of 480 mg/day, which is consistent with heavy -contact soil exposure. An 8 hour workday, which occurs on 85% of the regular workdays available for outdoor work (weather permitting) over a ten month time period (or 10 months x 4.3 weeks/month x 5 days/week x 0.85 = approximately 185 days) is used in this assessment. While the construction scenario only consists of a short-term, one-time (period) exposure, it may be still represent a bounding estimate for the onsite areas due to the nature of the health end-point considered for lead. Other parameter values for this scenario are also summarized in Table 1.

3.4 Toxicity

The toxic effects of lead have been well characterized and are described in the abundance of publications on this topic. Toxic effects involve several target organ systems with the most sensitive effects occurring in the central nervous system in infants and children. Very severe exposure in children (blood lead levels greater than 80 ug/dL) can cause coma, convulsions and even death. Lower blood lead levels can result in adverse effects on the central nervous system, kidney and hematopoietic system. Common symptoms in children include anemia, learning and language deficits, and attention span disorders which often lead to disruptive behavior. Blood lead levels as low as 10 ug/dL, which may not cause distinctive symptoms, are associated with decreased intelligence and impaired neurobehavioral development. Other effects which begin at these low blood lead levels include decreased stature or growth, decreased hearing acuity, decreased ability to maintain a steady posture, and impairment of the synthesis of the active metabolite 1,25-(OH)₂ vitamin D.

Studies have also indicated that deficits in mental development can occur in children born to mothers with elevated blood lead levels. While women of child-bearing age are not per se at risk from slightly elevated blood lead levels, they are also considered a sensitive population due to the transfer of lead via blood through the umbilical cord to the developing fetus during pregnancy. Maternal and cord blood lead levels of 10-15 ug/dL appear to be associated with reduced gestational age and reduced weight at birth as well.

EPA, as well as CDC and other federal and state agencies, has identified 10 ug/dL as the blood lead level of concern for children under the age of six, and EPA recommends in the current Office of Solid Waste and Emergency Response (OSWER) guidance that cleanup goals be established to limit the risk of exceeding a blood lead level of 10 ug/dL for children in this age range to 5% or less (EPA 1994). A similar goal has been adopted by EPA for the protection of fetuses carried by women who experience non-residential lead exposures. This is consistent with the recommendations of the National Research Council Committee on Measuring Lead in Critical Populations in their report (NRC 1996) for a target blood lead level of 10 ug/dL in the developing fetus.

It should be noted that the choice of 10 ug/dL as the upper 95th percentile limit for the developing fetus does not imply that exposures at or above this level will definitely result in adverse health outcomes or that levels below 10 ug/dL are without risk in all individuals. It is anticipated that there is a graded increase in the severity of adverse health effects with increasing blood lead level.

3.5 Risk Assessment Methodology

The recommended Adult Lead Interim approach for assessing nonresidential adult risks utilizes a methodology to relate soil lead intake to blood lead concentrations in women of child-bearing age. It is conceptually similar to a slope factor approach for deriving RBRGs that had

been proposed by Bowers et al. (1994) and which was adapted for use at the California Gulch NPL site in Region 8 (U.S. EPA, 1995).

The basis for the calculation of the blood lead concentration in women of child-bearing age is the algorithm given by Equation 1 from the USEPA report "Recommendations of the Technical Review Workgroup for Lead for an Interim Approach to Assessing Risks Associated with Adult Exposures to Lead in Soil":

$$PbB_{adult,central} = PbB_{adult,0} + \frac{PbS \cdot BKS F \cdot IR_s \cdot AF_s \cdot EF_s}{AT} \quad (\text{Equation 1})$$

where:

$PbB_{adult,central}$ = Central estimate of blood lead concentrations ($\mu\text{g/dL}$) in adults (i.e., women of child-bearing age) that have site exposures to soil lead at concentration, PbS .

$PbB_{adult,0}$ = Typical blood lead concentration ($\mu\text{g/dL}$) in adults (i.e., women of child-bearing age) in the absence of exposures to the site that is being assessed.

PbS = Soil lead concentration ($\mu\text{g/g}$) (appropriate average concentration for individual).

$BKS F$ = Biokinetic slope factor relating (quasi-steady state) increase in typical adult blood lead concentration to average daily lead uptake ($\mu\text{g/dL}$ blood lead increase per $\mu\text{g/day}$ lead uptake).

IR_s = Intake rate of soil, including both outdoor soil and indoor soil-derived dust (g/day).

AF_s = Absolute gastrointestinal absorption fraction for ingested lead in soil and lead in dust derived from soil (dimensionless).

EF_s = Exposure frequency for contact with assessed soils and/or dust derived in part from these soils (days of exposure during the averaging period); may be taken as days per year for continuing, long term exposure.

AT = Averaging time; the total period during which soil contact may occur; 365 days/year for continuing long term exposures.

Equation 2 describes the estimated relationship between the blood lead concentration in

adult women and the corresponding 95th percentile fetal blood lead concentration ($PbB_{fetal, 0.95}$), assuming that $PbB_{adult, central}$ reflects the geometric mean of a lognormal distribution of blood lead concentrations in women of child-bearing age. If a similar 95th percentile goal is applied to the protection of fetuses carried by women who experience nonresidential exposures, Equation 2 can be rearranged to reflect a risk-based goal for the central estimate of blood lead concentrations in adult women using Equation 3:

$$PbB_{fetal, 0.95} = PbB_{adult, central} \cdot GSD_{i, adult}^{1.645} \cdot R_{fetal/maternal} \quad (\text{Equation 2})$$

$$PbB_{adult, central, goal} = \frac{PbB_{fetal, 0.95, goal}}{GSD_{i, adult}^{1.645} \cdot R_{fetal/maternal}} \quad (\text{Equation 3})$$

where:

$PbB_{adult, central, goal}$ = Goal for central estimate of blood lead concentration ($\mu\text{g/dL}$) in adults (i.e., women of child-bearing age) that have site exposures. The goal is intended to ensure that $PbB_{fetal, 0.95, goal}$ does not exceed $10 \mu\text{g/dL}$.

$PbB_{fetal, 0.95, goal}$ = Goal for the 95th percentile blood lead concentration ($\mu\text{g/dL}$) among fetuses born to women having exposures to the specified site soil concentration. This is interpreted to mean that there is a 95% likelihood that a fetus, in a woman who experiences such exposures, would have a blood lead concentration no greater than $PbB_{fetal, 0.95, goal}$ (i.e., the likelihood of a blood lead concentration greater than $10 \mu\text{g/dL}$ would be less than 5%, for the approach described in this report).

$GSD_{i, adult}$ = Estimated value of the individual geometric standard deviation (dimensionless); the GSD among adults (i.e., women of child-bearing age) that have exposures to similar on-site lead concentrations, but that have non-uniform response (intake, biokinetics) to site lead and non-uniform off-site lead exposures. The exponent, 1.645, is the value of the standard normal deviate used to calculate the 95th percentile from a lognormal distribution of blood lead concentration.

$R_{\text{fetal/maternal}}$ = Constant of proportionality between fetal blood lead concentration at birth and maternal blood lead concentration (dimension less).

The method for modifying the equations for the calculation of fetal risk are further clarified in a subsequent memorandum (presently in draft form) prepared by Paul White and me. These equations represent a rearrangement of the equations from the Interim Adult Approach report in a format which allows for the direct estimation of the fetal risk from adult lead exposure to specified levels of soil contamination. This methodology was used in the risk calculations in this report and supports EPA's goal of limiting the risk of elevated fetal blood lead concentrations in women of child-bearing age.

The adult lead risk assessment methodology is based on a lognormal probability model for blood levels in adult women exposed to lead contaminated soils, coupled with an estimated constant of proportionality between fetal and maternal blood lead levels. These relationships mean that the distribution of fetal blood lead levels also follows a lognormal distribution:

$$PbB_{\text{fetal}} \sim \text{Lognormal}(GM, GSD)$$

Calculation of the probability that fetal blood lead levels will exceed the EPA blood lead level of concern of 10 ug/dL is a two step process:

(1) Calculate the geometric mean (central) fetal blood lead concentration ($PbB_{\text{fetal,GM}}$). Equation A-3 in the document appendix provides an estimate of the central tendency adult blood lead level which is used to provide a plausible estimate of the geometric mean in the lognormal model for blood lead. When the expressions for lead UPTAKE (Equations A-1 and A2) are substituted into Equation A-3 we obtain the following relationship:

$$PbB_{\text{adult,central}} = PbB_{\text{adult,0}} + \frac{PbS \cdot BKS F \cdot IR_s \cdot AF_s \cdot EF_s}{AT}$$

Equation A-5 then provides the constant of proportionality between fetal and adult blood lead levels:

$$PbB_{\text{fetal}} = R_{\text{fetal/maternal}} \cdot PbB_{\text{adult}}$$

The resulting equation for the fetal geometric mean blood lead level has the following form:

$$PbB_{fetal,GM} = R_{fetal/maternal} \cdot [PbB_{adult,0} + \frac{PbS \cdot BKSF \cdot IR_s \cdot AF_s \cdot EF_s}{AT}] \quad \text{Equation 4}$$

Where:

- $PbB_{fetal,GM}$ = Central estimate of fetal blood lead concentrations ($\mu\text{g/dL}$) in adults (i.e., women of child-bearing age) that have site exposures to soil lead at concentration, PbS .
- $R_{fetal/maternal}$ = Constant of proportionality between fetal and maternal blood lead concentrations.
- $PbB_{adult,0}$ = Typical blood lead concentration ($\mu\text{g/dL}$) in adults (i.e., women of child-bearing age) in the absence of exposures to the site that is being assessed.
- PbS = Soil lead concentration ($\mu\text{g/g}$) (appropriate average concentration for individual).
- $BKSF$ = Biokinetic slope factor relating (quasi-steady state) increase in typical adult blood lead concentration to average daily lead uptake ($\mu\text{g/dL}$ blood lead increase per $\mu\text{g/day}$ lead uptake).
- IR_s = Intake rate of soil, including both outdoor soil and indoor soil-derived dust (g/day).
- AF_s = Absolute gastrointestinal absorption fraction for ingested lead in soil and lead in dust derived from soil (dimensionless).
- EF_s = Exposure frequency for contact with assessed soils and/or dust derived in part from these soils (days of exposure during the averaging period); may be taken as days per year for continuing, long term exposure.
- AT = Averaging time; the total period during which soil contact may occur; 365 days/year for continuing long term exposures.

(2) Determine the probability that the blood lead level for a fetus carried by a woman exposed to lead at a site exceeds 10 $\mu\text{g/dL}$. This calculation uses the fetal geometric mean (GM) blood lead from Equation 4 and the geometric standard deviation (GSD) value appropriate for the risk assessment. Note that because of the assumption of proportionality between fetal and maternal blood lead levels the adult GSD and the fetal GSD are equal. If the assessor is using a spreadsheet or statistical program that provides a function to calculate lognormal probabilities, the GM and GSD values may directly used to calculate the exceedence probabilities. (Care must be taken to determine exact form of the inputs needed by the statistical function, e. g., whether log scale inputs are required.) Alternatively, the following formula and table provide the needed tools for the probability calculation.

The logarithm of a lognormal variable follows a normal probability distribution. Exceedence probabilities for the lognormal model can be determined from standard normal model statistical tables after the GM, GSD, and exceedence criterion are converted to log scale values and a “standard normal deviate” or “z-value” is calculated:

$$\begin{array}{l} \text{Standard normal deviate} \\ \text{for a blood lead level of 10 ug/dL} \\ \text{using the specified GM and GSD} \end{array} = \frac{\log 10 - \log \text{GM}}{\log \text{GSD}} = \text{z-value} \quad \text{Equation 5}$$

A standard normal probability table can then be used to determine the exceedence probability. Most tables displays both positive and negative z-values for ease of reference. As the table displays the probability of having a value less than z, the probability that the fetal blood lead level exceeds 10 ug/dL is obtained by from the expression “1 minus the value”.

Use of the Methodology for Short Term Exposures Based on estimates of the first order elimination half-time for lead in blood of approximately 30 days for adults (Rabinowitz, et al., 1974, 1976; Chamberlain et al., 1978), a constant lead intake rate over a duration of 90 days would be expected to achieve a blood lead concentration that is sufficiently close the quasi-steady state. This is the minimum exposure duration to which this methodology should be applied. Infrequent exposures (i.e., less than 1 day per week) over a minimum duration of 90 days would be expected to produce oscillations in blood lead concentrations associated with the absorption and subsequent clearance of lead from the blood between each exposure event. Based on the above assumptions about the elimination half-time lead in blood, this methodology should not be applied to scenarios in which exposure frequency is less than 1 day/week. The scenarios in this risk evaluation were constructed to be consistent with these limitations.

3.6 Calculation of Risk Related to Lead Exposure

The parameter input values used in the calculations of risk to the onsite worker and potential construction workers are shown in Table 3. Default values were used for the fetal blood lead goal ($\text{PbB}_{\text{fetal}, 0.95, \text{goal}}$), the fetal/maternal blood lead ratio (R), the BKSF, and the absorption fraction (AF_s). In addition, a GSD of 1.8 was used in this calculation, based on the assumption that the work exposures and habits in the Cleveland area are relatively homogeneous. Scenario specific values used for other input parameters are discussed further and are also summarized in Table 3.

Baseline Blood Lead Concentration The baseline blood lead concentration ($\text{PbB}_{\text{adult}, 0}$) is intended to represent the best estimate of a reasonable central value of blood lead concentration in women of child-bearing age who are not exposed to lead-contaminated nonresidential soil or dust at the site. In this analysis, geometric mean blood lead concentrations are used for this purpose. Ideally, the value(s) for $\text{PbB}_{\text{adult}, 0}$ used in the methodology should be estimated in the population of concern at the site. In cases where site-specific extrapolations from surrogate

populations are not feasible, values of 1.7 - 2.2 $\mu\text{g/dL}$ are recommended as a plausible range for the general population of women of child-bearing age, i.e., ages 17 - 49, based on the results of Phase 1 of the NHANES III as reported by Brody et al. (1994) (Table 4). A value of 2.0 for $\text{PbB}_{\text{adult},0}$, consistent with the assumption of a mixed racial worker population, appears to be most appropriate for this site.

Ingestion Rate The default soil/dust ingestion rate of 50 mg/day was used as a reasonable input value for the general worker population, while an average soil ingestion rate of 100 mg/day was considered more appropriate for the more heavily exposed construction worker population, who is considered to work in close contact with the outdoor environment and may experience periodic episodes of soil ingestion up to 480 mg/day (a value considered appropriate for soil-intense exposure). These values are consistent with the use of central tendency input values as specified in the Adult Interim methodology. It should be noted that the lower ingestion rate of 50 mg/day is considered appropriate only for non-contact intensive exposures, such as those expected for an indoor worker such as a secretary or engineer.

Exposure Frequency and Averaging Time For the onsite commercial/industrial worker, the default EF value of 250 days/year and default AT value of 365 days/year were used. For the construction worker, onsite exposure was assumed to occur for 185 days over a 43 week period or 10 month period (AT = 301 days).

Lead Exposure Point Concentration The exposure point concentrations used in the risk calculations were chosen to consider both exposure to site-related activities at specific locations (focused exposures) and site activities which result in exposure to the entire onsite area on a routine basis. For the general commercial/industrial worker population, both the exposure to the mean onsite soil lead concentration in surface soil (0-6 inches segment) and to the maximum onsite soil lead concentration in surface soil detected in sample ONS-07, as a bounding estimate, were evaluated. The construction scenario is considered to be a more conservative scenario. For this reason, both a range of soil lead concentrations which represent the depth-weighted averages of lead concentrations detected in onsite soils and the site-wide arithmetic mean depth-weighted concentration were used in this assessment. The data used are summarized in Tables 1 and 2.

3.7 Risk Estimates

Using the above parameter values and the described equations result in an estimate of the geometric mean fetal blood lead concentration for an onsite commercial/industrial adult worker that has site exposure to soil lead (based on adult women of child-bearing age) of **23.4 $\mu\text{g/dL}$** , based on exposure to the average soil lead concentration in surface soil. This predicted mean fetal blood lead level greatly exceeds the blood lead level of 10 $\mu\text{g/dL}$, indicating a potential for extreme risk to women of child-bearing age who would be employed in a commercial/industrial facility located onsite. The calculated probability of exceeding the 10 $\mu\text{g/dL}$ blood lead level of

concern is approximately **93%**. Use of the maximum surface soil lead concentration detected onsite gives a bounding estimate of the geometric mean fetal blood lead concentration of approximately **53 ug/dL**. Obviously, these estimates do not represent realistic values, as the exposure to soil lead concentrations of this magnitude violate all assumptions of steady-state biokinetic rates in the maternal and fetal compartments. These estimates are presented only to illustrate the magnitude of the hazard posed by the remaining onsite lead surface soil concentrations.

The estimated range of predicted geometric mean fetal blood lead concentrations for the onsite construction worker is **5.8 - 32 ug/dL**, using a range of onsite depth-weighted soil lead estimates for site-related activities focused at specific locations (locations ONS-02 at 1,494 mg/kg and ONS-07 at 11,531 mg/kg). The risk calculations give an estimate of the range of the probability of exceeding a mean fetal blood lead level of 10 ug/dL of **17 - 98 %**, which exceed the EPA goal. Use of the mean depth-weighted soil lead concentration of 6,225 mg/kg results in predicted geometric mean blood lead level in the fetus of approximately **18 ug/dL**, which already exceeds the target fetal blood lead level of 10 ug/dL.

3.8 Other Sampling Data

A review of the site perimeter XRF measurements from 19 surface soil samples taken at the site fence-line shows an arithmetic mean soil lead concentration of 8,664 mg/kg, with a range of 931 to 36,587 mg/kg at individual sampling locations. A hypothetical worker scenario could be envisioned which would allow equal opportunity for exposure to all sampling locations on a routine basis, such as a daily lunch-time walk or travel to and from a vehicle parked on the surrounding streets. Such activities might result in the transport of contaminated soil to indoor areas as well. Applying the indoor worker based risk parameters to the calculation of such a scenario results in a predicted geometric mean blood lead level of approximately **15 ug/dL**, again a value that exceeds the target blood lead level of 10 ug/dl. Therefore, exposure these perimeter surface soil lead concentrations cannot be considered to be without risk.

The 1998 EE/CA Data Report also presents data for samples taken at varying distance from the site property. The text indicates that the average soil lead concentration for these nine off-site samples (OS-01-03 to OS-09-03) is 375 mg/kg, and goes on further to compare this average soil lead concentration with the Superfund soil lead screening level of 400 mg/kg. Averaging of samples taken at random to determine if they present a risk, without consideration of the exposure scenario does not seem to make much sense as samples should only be combined in a manner that is consistent with the exposure to some population of concern. No scenario where an off-site receptor would have equal opportunity for exposure to each of the off-site sampling points on a routine basis could be envisioned.

A better comparison to the lead soil screening value would be offered by looking at each of the off-site sampling point concentration and comparing it to the relevant receptor population.

As this appears to be a commercial-industrial area, the relevant receptor would be an area worker. Alternately, the three samples in the triangular area bounded by Quiglet Avenue, west Seventh Street and the I-490 Bypass might be averaged to look at the exposure in this more confined area. The average lead soil concentration in this area, as defined by samples OS-07-03, OS-08-03 and OS-09-03, is 590 mg/kg. Use of this triangular area for any recreational activity could potentially result in exposure to a resident population as the average soil lead exceeds the residential soil lead screening level of 400 ppm. No further analysis was performed on this data as only the soil concentrations in the triangular area were considered to present a risk, and then only to children frequenting this area. This does not seem to be a real probability. I am not certain that I agree with the remainder of the text in this section of the EE/CA Data Report, which suggests that other sources (i.e., the I-490 Bypass) might contribute to lead in this area. If this is the reason why the lead concentration at sampling point OS-08-03 is elevated, it is then not clear why the soil lead concentration at point OS-09-03 is so low (170 mg/kg).

Some data on the recent groundwater sampling is also presented in the Data Report. In discussion of this data, the text states that "it is evident that heavy metals from this site are not partitioning to the groundwater". However, from the data presented, it is not clear that this is the case because the 1991 CDI data does not indicate whether it represents data for the total or dissolved fraction. The data presented could be interpreted to mean that the lead is migrating to groundwater at a constant, or perhaps even increased, rate. This would indicate a need to address lead in surface soil as well as lead in subsurface soil.

3.9 Uncertainty in the Lead Risk Analysis

All risk estimates require the use of input parameter values and assumptions which are uncertain. Perhaps the greatest uncertainty can be found in the exposure assumptions, which seek to define conditions for contact by both onsite commercial/industrial worker and construction worker populations with contaminated site soils. The assumptions used in this assessment are conservative; however they do not represent a worst case scenario. The Interim Adult Lead Methodology discusses the rationale for the use of many, if not most, of the input parameter values used in these calculations. Most can be viewed as reasonable, as they are based on empirical data or realistic assumptions.

As previously discussed, the comparison between all XRF measured total lead concentration values and Laboratory measured total lead concentration values reported in the EE/CS Data Report create uncertainty regarding the accuracy of the lead concentrations reported by XRF analysis. A **2.65 fold average increase in lead concentration** in samples analyzed in the Laboratory versus samples analyzed by XRF was seen in six of seven onsite samples, whose XRF measurements ranged from 110 mg/kg to 12,580 mg/kg. One sample (ONS-04-12), which was not included in the averaging, exhibited a **26 fold increase** in the laboratory analysis. For the four perimeter samples (whose XRF reading ranged from 72 mg/kg to 409 mg/kg), the average difference between XRF and laboratory values was less pronounced (1.2). This data

creates uncertainty as to whether the predictions of already greatly elevated fetal blood lead concentrations seen in the risk calculations shown earlier are even higher.

Also discussed earlier were two additional problems in the use of the EE/CA surface soil data for lead risk assessment. Because the usual pathway of exposure to soil dust is incidental ingestion, it is assumed that the soil which is available for the worker ingestion comes from the surface soil dust fraction - i.e., the top two inches of soil and that fraction of total soil which passes through a 250 micron (100 mesh) sieve. The use of surface soil samples collected over a six inch depth further introduces an unknown dilution factor in the surface soil data measurements from bore samples. In addition, numerous analyses of both total and fine soil lead fractions have shown that lead concentrations tend to increase in the fine particulate fraction, especially if the source is airborne deposition. Stern has suggested in his lead model that an adjustment to the total soil lead concentration be included in the risk calculations to reduce some of the under prediction caused by the use of total soil lead data. Both problems would seem to be relevant to the Master Metals site.

For the all reasons stated above, it is expected that any risk calculations performed using the EE/CA data collected at this site are likely to be underestimations.

4.0 Calculation of Cleanup Goals (CUG)

4.1 Methodology for Calculating CUG for Lead

The basis for the RBRG calculation is the relationship between the soil lead concentration and the blood lead concentration in the developing fetus of adult women that have site exposures. As a health-based goal, EPA has sought to limit the risk to young children of having elevated blood lead concentrations. Current Office of Solid Waste and Emergency Response (OSWER) guidance calls for the establishment of cleanup goals to limit childhood risk of exceeding 10 µg/dL to 5% (U.S. EPA, 1994a).

The soil lead concentration associated with a given exposure scenario and $PbB_{adult, central, goal}$ can be calculated by rearranging Equation 1 (section 3) and substituting $PbB_{adult, central, goal}$ for $PbB_{adult, central}$:

$$RBRG = PbS = \frac{(PbB_{adult, central, goal} - PbB_{adult, 0}) \cdot AT}{(BKS F \cdot IR_s \cdot AF_s \cdot EF_s)} \quad (\text{Equation 6})$$

This equation calculates the lead risk-based remediation goal (RBRG), where the RBRG

represents the soil lead concentration (PbS) that would be expected to result in a specified adult blood lead concentration ($PbB_{\text{adult, central, goal}}$) and corresponding 95th percentile fetal blood lead concentration ($PbB_{\text{fetal, 0.95, goal}}$).

The primary basis for using Equation 6 to calculate a RBRG is that fetuses and neonates are a highly sensitive population with respect to the adverse effects of lead and that 10 $\mu\text{g/dL}$ is considered to be a blood lead level of concern from the standpoint of protecting the health of sensitive populations (U.S. EPA, 1986, 1990; NRC, 1993). Therefore, risk to the fetus can be estimated from the probability distribution of fetal blood lead concentrations (i.e., the probability of exceeding 10 $\mu\text{g/dL}$), as has been the approach taken for estimating risks to children (U.S. EPA, 1994a,c). Equation 6 can be used to estimate the soil lead concentration at which the probability of blood lead concentrations exceeding a given value (e.g., 10 $\mu\text{g/dL}$) in fetuses of women exposed to environmental lead is no greater than a specified value (e.g., 0.05 or 5%).

4.2 Site CUG for Lead

The parameter input values used in the calculations of site soil lead cleanup goals, consistent with the site scenarios previously described, are shown in Table 3. Default values were used for the fetal blood lead goal ($PbB_{\text{fetal, 0.95, goal}}$), the fetal/maternal blood lead ratio (R), the BKSF, and the absorption fraction (AF_s). In addition, a GSD of 1.8 was used in this calculation, based on the assumption that the work exposures and habits in the Cleveland area are relatively homogeneous. This results in an estimate of 4.225 $\mu\text{g/dL}$ for the maternal target blood lead goal ($PbB_{\text{adult, central, goal}}$).

Calculation of an onsite soil lead clean-up goal based on exposure to a typical commercial/industrial worker, and using parameter input values consistent with the calculation of the risk to the worker, results in a clean-up goal for lead in onsite soil of 1354 mg/kg (rounded to **1350 mg/kg**).

Calculations using input parameter values consistent with the construction worker exposure yielded a soil lead clean-up range of 754 mg/kg (rounded to **750 ppm**). The clean-up goal for the construction worker would also be protective for heavy industrial worker exposure, which is defined in this context as worker activities which result in routine exposure with the outdoor environment. A CUG that is protective for the construction worker population is also protective for a typical onsite commercial/industrial worker.

Because perimeter surface soil samples also show high elevations of lead contamination and reasonable scenarios, in addition to the one presented, can be constructed which would allow exposure to onsite worker populations, these areas should be addressed as well.

5.0 Conclusions and Recommendations

The risk evaluation calculations described above determined that risk to the construction worker presents the greatest risk from lead exposure in onsite soil. . For this reason, calculation of an onsite soil lead clean-up based on the construction worker scenario, and using parameter input values consistent with the calculation of the exposure to this worker population, represents the most reasonable approach. **The resulting clean-up goal for lead in onsite soil is 750 mg/kg.**

Because the long term use of the site as an industrial area cannot be determined, and more importantly, because the behavior of future onsite workers cannot be predicted , any location could result in risk if routine outdoor exposure was concentrated in that area. **This memo, therefore, recommends that all onsite soil which exceeds the CUG level of 750 ppm be addressed in the response action.**

It should be noted that the recommended actions may not reduce the contaminant concentration to a level which is acceptable for residential or recreational exposure, and no such development or change in the land use should be considered without further evaluation of risk for the child as the population of concern.

6.0 References

Balbus-Kornfeld, J. 1994. Comments and Recommendations on the Draft Interim Guidance for Screening Levels of Lead in Soil for Non-Residential Sites. Letter from John Balbus-Kornfeld to Bruce Means. November 17, 1994.

Bowers, TS, BD Beck and HS Karam. 1994. Assessing the relationship between environmental lead concentrations and adult blood lead levels. Risk Analysis 14: 183-189.

Brody, DJ, JL Pirkle, RA Kramer, KM Flegal, TD Matte, EW Gunter and DC Paschal. 1994. Blood lead levels in the U.S. population. Phase 1 of the third National Health and Nutrition Examination Survey (NHANES III, 1988 to 1991). JAMA 272: 277-283.

Chamberlain, A.C., M.J. Heard, P. Little, D. Newton, A.C. Wells and R.D. Wiffen. 1978. Investigations into lead from motor vehicles. Harwell, United Kingdom: United Kingdom Atomic Energy Authority, Report No. AERE-R9198.

Entact. 1998. Engineering Evaluation and Cost Analysis (EE/CA) Data Report for the Master Metals, Inc. Site, prepared January 19, 1998.

NRC. 1993. National Research Council Committee on Measuring Lead in Critical Populations, Measuring Lead Exposure in Infants, Children, and Other Sensitive Populations. National Academy Press, Washington, D.C. ISBN 0-309-04927-X.

Pocock, S.J., A.G. Shaper, M. Walker, C.J. Wale, B. Clayton, T. Delves, R.F. Lacey, R.F. Packham and P. Powell. 1983. Effects of tap water lead, water hardness, alcohol, and cigarettes on blood lead concentrations. J. Epidemiol. Commun. Health. 37: 1-7.

Rabinowitz, M.B., G.W. Wetherill and J.D. Koppel. 1974. Studies of human lead metabolism by use of stable isotope tracers. Environ. Health Perspect. 7: 145-153.

Rabinowitz, M.B., G.W. Wetherill and J.D. Koppel. 1976. Kinetic analysis of lead metabolism in health humans. J. Clin. Invest. 58: 260-270.

U.S. EPA. 1993. Superfund's Standard Default Exposure Factors for the Central Tendency and RME-Draft. Working Draft, November 1993.

U.S. EPA. 1994a. Revised Interim Soil Lead Guidance for CERCLA Sites and RCRA Corrective Action Facilities. OSWER Directive No. 9355.4-12. Office of Emergency and Remedial Response, Washington, D.C. EPA/540/F-94/043, PB94-963282.

U.S. EPA. 1994b. Technical Support Document: Parameters and Equations Used in the Integrated Exposure Uptake Biokinetic Model for Lead in Children (v. 0.99d). Office of Emergency and Remedial Response, Washington, D.C. EPA/540/R-94/040, PB94-963505.

U.S. EPA. 1994c. Guidance Manual for the Integrated Exposure Uptake Biokinetic Model for Lead in Children. Office of Emergency and Remedial Response, Washington, D.C. EPA/540/R-93/081, PB93-963510.

U.S. EPA. 1995. A TRW Report: Review of a Methodology for Establishing Risk-Based Soil Remediation Goals for the Commercial Areas of the California Gulch Site. Technical Review Workgroup for Lead, October, 1995.

U.S. EPA 1996. A TRW Report: Recommendations of the Technical Review Workgroup for Lead for an Interim Approach to Assessing Risks Associated with Adult Exposures to Lead in Soil. Technical Review Workgroup for Lead, December 1996.

**Table 1 . Data used in calculation of Exposure Point Concentration
For the Onsite Worker Scenario**

Location	XRF Pb Concentration in 0-6" segment (mg/kg)
ONS-01	10,433
ONS-02	6,397
ONS-03	28,500
ONS-04	12,067
ONS-05	10,193
ONS-05	110
ONS-07	34,320
	 $\bar{x} (7) = 14,574 \pm 12,264 \text{ mg/kg}$ $\text{UCL} (7) = 22,200 \text{ mg/kg}$

**Table 2 . Data used in calculation of Exposure Point Concentration -
For the Construction Worker Scenario**

Location	XRF Pb Concentration (mg/kg)				
	0-6" weight = 0.5	6-12" weight = 0.5	12-24" weight = 1.0	24-36" weight = 1.0	Depth-weighted Average
ONS-01	10,433	7,737	12,580*	-	10,250
ONS-02	6,397	1,366	412	187	1,494
ONS-03	28,500	9,740	582	464	6,722
ONS-04	12,067	462	52	1,603	2,640
ONS-05	10,193	5,087	4,123	-	5,882
ONS-06	110	15,353	2,383	-	5,057
ONS-07	34,320	1,458	5,173	-	11,531
					$\bar{x} = 6,225 \pm 3,681$

Note: The total weight is determined by the number of segments analyzed for each boring.

* This sample represents the 12-18" fraction. Weight = 0.5/1.5.

Table 3. Summary of Default Parameter Values in Risk Estimation Equations

Parameter	Unit	Default Value	Onsite Worker Scenario	Construction Worker Scenario
$PbB_{fetal, 0.95, goal}$	$\mu\text{g/dL}$	10	10	10
$GSD_{i, adult}$	--	1.8, 2.1	1.8	1.8
$R_{fetal/maternal}$	--	0.9	0.9	0.9
$PbB_{adult, 0}$	$\mu\text{g/dL}$	1.7-2.2	2.0	2.0
BKSF	$\mu\text{g/dL}$ per $\mu\text{g/day}$	0.4	0.4	0.4
IR_s	g/day	0.05	0.05	0.100
EF_s	day/yr	219	250	185
AT	days/yr	365	365	301
AF_s	--	0.12	0.12	0.12

**Table 4. NHANES III Phase 1 Summary Statistics for Blood Lead Concentration
Among U.S. Women by Age and Ethnic/Racial Characteristics ^a**

Age Group (years)	Non-Hispanic White			Non-Hispanic Black			Mexican American		
	No.	GM	GSD	No.	GM	GSD	No.	GM	GSD
12 - 19	237	1.0		197	1.8		254	1.5	
20 - 49	728	1.9	1.90	622	2.3	2.01	729	2.1	2.10
50 - 69	476	3.2	1.88	256	4.2	1.80	255	3.3	2.12
> 69	562	3.5	1.82	135	4.1	1.86	75	2.9	2.03
20 +	1,766	2.4	2.01	1,013	2.7	2.07	1,059	2.3	2.14
17 - 45	742	1.7	1.89	658	2.1	1.98	763	2.0	2.10

^a Analysis of data weighted by MEC and home weighting factor (WTPEXMH1), excluding samples missing data on blood lead concentration or age.

GM PbB ($\mu\text{g/dL}$) = $\exp(\mu_{\ln})$; GSD PbB = $\exp(\sigma_{\ln})$